

## Supplementary Materials for:

# A techno-economic study of an entirely renewable energy based power supply for North America for 2030 conditions

Arman Aghahosseini\*, Dmitrii Bogdanov, Christian Breyer

Department of Electrical Engineering, School of Energy Systems, Lappeenranta University of Technology, Skinnarilankatu 34, 53850 Lappeenranta, Finland

\* Correspondence: arman.aghahosseini@lut.fi; Tel.: +358-41-3697925

**Table S1:** Financial assumptions for energy system components [59,77,78,101-105].

| Technology                | Capex<br>[€/kW]                     | Opex fix<br>[€/(kW·a)]                    | Opex var<br>[€/kWh]                  | Lifetime<br>[a] |
|---------------------------|-------------------------------------|-------------------------------------------|--------------------------------------|-----------------|
| PV optimally tilted       | 550                                 | 8                                         | 0                                    | 35              |
| PV single-axis tracking   | 620                                 | 9                                         | 0                                    | 35              |
| PV rooftop                | 813                                 | 12                                        | 0                                    | 35              |
| Wind onshore              | 1000                                | 20                                        | 0                                    | 25              |
| CSP (solar field)         | 528                                 | 11                                        | 0                                    | 25              |
| Hydro run-of-river        | 2560                                | 115.2                                     | 0.005                                | 60              |
| Hydro dam                 | 1650                                | 66                                        | 0.003                                | 60              |
| Geothermal energy         | 4860                                | 87                                        | 0                                    | 30              |
| Water electrolysis        | 380                                 | 13                                        | 0.0012                               | 30              |
| Methanation               | 234                                 | 5                                         | 0.0015                               | 30              |
| CO <sub>2</sub> scrubbing | 356                                 | 14                                        | 0.0013                               | 30              |
| CCGT                      | 775                                 | 19.4                                      | 0.001                                | 30              |
| OCGT                      | 475                                 | 14.25                                     | 0.001                                | 30              |
| Steam turbine             | 600                                 | 12                                        | 0                                    | 30              |
| Hot heat burner           | 100                                 | 2                                         | 0                                    | 30              |
| Heating rod               | 20                                  | 0.4                                       | 0.001                                | 30              |
| Biomass CHP               | 2500                                | 175                                       | 0.001                                | 30              |
| Biogas CHP                | 370                                 | 14.8                                      | 0.001                                | 30              |
| Waste incinerator         | 5240                                | 235.8                                     | 0.007                                | 20              |
| Biogas digester           | 680                                 | 27.2                                      | 0                                    | 20              |
| Biogas upgrade            | 250                                 | 20                                        | 0                                    | 20              |
|                           | Capex<br>[€/kWh]                    | Opex fix<br>[€/(kWh·a)]                   | Opex var<br>[€/kWh]                  | Lifetime<br>[a] |
| Battery system            | 150                                 | 10                                        | 0.0002                               | 10/20           |
| Battery prosumer          | 150                                 | 10                                        | 0.0002                               | 10              |
| PHS                       | 70                                  | 11                                        | 0.0002                               | 50              |
| A-CAES                    | 31                                  | 0.4                                       | 0.0012                               | 40              |
| TES                       | 24                                  | 2                                         | 0                                    | 20              |
| Gas storage               | 0.05                                | 0.001                                     | 0                                    | 50              |
|                           | Capex<br>[€/kW <sub>NTC</sub> ·km]  | Opex fix<br>[€/(kW <sub>NTC</sub> ·km·a)] | Opex var<br>[€/kWh <sub>NTC</sub> ]  | Lifetime [a]    |
| HVDC line on ground       | 0.612                               | 0.0075                                    | 0                                    | 50              |
| HVDC line submarine       | 0.992                               | 0.0010                                    | 0                                    | 50              |
|                           | Capex<br>[€/kW <sub>NTC</sub> ]     | Opex fix<br>[€/(kW <sub>NTC</sub> ·a)]    | Opex var<br>[€/kWh <sub>NTC</sub> ]  | Lifetime [a]    |
| HVDC converter pair       | 180                                 | 1.8                                       | 0                                    | 50              |
|                           | Capex<br>[€/(m <sup>3</sup> ·a)]    | Opex fix<br>[€/(m <sup>3</sup> ·a)]       | Opex var<br>[€/m <sup>3</sup> ]      | Lifetime [a]    |
| Water desalination        | 2.23                                | 0.09                                      | 0                                    | 30              |
|                           | Capex<br>[€/(m <sup>3</sup> ·h·km)] | Opex fix<br>[€/(m <sup>3</sup> ·h·km·a)]  | Opex var<br>[€/m <sup>3</sup> ·h·km] | Lifetime [a]    |

|                              |      |      |   |    |
|------------------------------|------|------|---|----|
| Horizontal pumping and pipes | 19.3 | 0.39 | 0 | 30 |
| Vertical pumping and pipes   | 15.5 | 0.31 | 0 | 30 |

**Table S2:** Efficiencies and energy to power ratio of storage technologies.

| Technology  | Efficiency [%] | Energy/Power Ratio [h] | Self-Discharge [%/h] |
|-------------|----------------|------------------------|----------------------|
| Battery     | 90             | 6                      | 0                    |
| PHS         | 85             | 8                      | 0                    |
| A-CAES      | 70             | 100                    | 0.001                |
| TES         | 90             | 8                      | 0.002                |
| Gas storage | 100            | 80*24                  | 0                    |

**Table S3:** Efficiency assumptions for energy system components for the year 2030.

|                           | $\eta_{el}$ [%] | $\eta_{th}$ [%] |
|---------------------------|-----------------|-----------------|
| CSP (solar field)         |                 | 51              |
| Steam turbine             | 42              |                 |
| Hot heat burner           |                 | 95              |
| Heating rod               |                 | 99              |
| Water electrolysis        |                 | 84              |
| Methanation               |                 | 77              |
| CO <sub>2</sub> scrubbing |                 | 78              |
| CCGT                      | 58              |                 |
| OCGT                      | 43              |                 |
| Geothermal                | 24              |                 |
| Biomass CHP               | 40              | 45              |
| Biogas CHP                | 42              | 43              |
| Waste incinerator         | 34              |                 |
| Biogas upgrade            |                 | 98              |

**Table S4:** Efficiency assumptions for HVDC transmission.

|                     | Power losses    |
|---------------------|-----------------|
| HVDC line           | 1.6 % / 1000 km |
| HVDC converter pair | 1.4%            |

**Table S5:** Regional end-user grid electricity costs for the year 2030. For the sub-regions, electricity costs are the weighted average of all cities within the sub-region.

| Region                        | Electricity costs [€/MWh] |            |            |
|-------------------------------|---------------------------|------------|------------|
|                               | Residential               | Commercial | Industrial |
| Total area (weighted average) | 169                       | 174        | 154        |
| CA-West                       | 162                       | 164        | 153        |
| CA-East                       | 151                       | 179        | 172        |
| US-New England & New York     | 205                       | 194        | 164        |
| US-Mid-Atlantic               | 186                       | 178        | 145        |
| US-Carolinas                  | 186                       | 175        | 151        |
| US-Southern                   | 182                       | 179        | 154        |
| US-TVA                        | 166                       | 169        | 127        |
| US-Midwest                    | 182                       | 170        | 148        |
| US-Central                    | 175                       | 167        | 145        |
| US-Texas                      | 176                       | 162        | 137        |
| US-Southwest                  | 181                       | 167        | 137        |
| US-Northwest                  | 158                       | 144        | 126        |

|                                 |     |     |     |
|---------------------------------|-----|-----|-----|
| US-California                   | 210 | 205 | 187 |
| US-Alaska                       | 309 | 296 | 209 |
| US-Hawaii                       | 358 | 354 | 342 |
| US-Gulf                         | 160 | 161 | 131 |
| MX-Noroeste (Northwest)         | 103 | 176 | 176 |
| MX-Noreste (North)              | 104 | 175 | 175 |
| MX-Centro-Occidente (Center)    | 105 | 186 | 186 |
| MX-Centro & Sur-Sureste (South) | 102 | 182 | 182 |

**Table S6:** Regional biomass potentials and geothermal energy potentials.

| Region                          | Biomass potential [TWh <sub>th</sub> /a] |               |                | Geothermal Potential [TWh <sub>th</sub> /a] |
|---------------------------------|------------------------------------------|---------------|----------------|---------------------------------------------|
|                                 | Solid waste                              | Solid biomass | Biogas sources |                                             |
| Total area                      | 97.8                                     | 1140.7        | 0.0            | 860.7                                       |
| CA-West                         | 6.3                                      | 155.7         | 0.0            | 176.1                                       |
| CA-East                         | 13.9                                     | 71.9          | 0.0            | 5.3                                         |
| US-New England & New York       | 7.1                                      | 26.1          | 0.0            | 0.0                                         |
| US-Mid-Atlantics                | 10.4                                     | 27.3          | 0.0            | 2.2                                         |
| US-Carolinas                    | 3.0                                      | 17.7          | 0.0            | 0.6                                         |
| US-Southern                     | 7.1                                      | 36.6          | 0.0            | 0.0                                         |
| US-TVA                          | 2.3                                      | 17.0          | 0.0            | 0.0                                         |
| US-Midwest                      | 10.6                                     | 127.3         | 0.0            | 124.9                                       |
| US-Central                      | 1.8                                      | 47.3          | 0.0            | 80.3                                        |
| US-Texas                        | 5.4                                      | 55.4          | 0.0            | 1.3                                         |
| US-Southwest                    | 7.2                                      | 104.4         | 0.0            | 21.1                                        |
| US-Northwest                    | 5.3                                      | 164.5         | 0.0            | 316.1                                       |
| US-California                   | 7.9                                      | 33.8          | 0.0            | 24.4                                        |
| US-Alaska                       | 0.2                                      | 135.4         | 0.0            | 15.2                                        |
| US-Hawaii                       | 0.3                                      | 2.3           | 0.0            | 0.0                                         |
| US-Gulf                         | 2.2                                      | 31.6          | 0.0            | 0.0                                         |
| MX-Noroeste (Northwest)         | 0.6                                      | 16.2          | 0.0            | 9.9                                         |
| MX-Noreste (North)              | 0.9                                      | 22.6          | 0.0            | 9.0                                         |
| MX-Centro-Occidente (Center)    | 1.6                                      | 18.4          | 0.0            | 54.1                                        |
| MX-Centro & Sur-Sureste (South) | 3.7                                      | 29.2          | 0.0            | 20.0                                        |

**Table S7:** Regional biomass costs, calculated based on biomass source mixes in the region. Solid wastes cost are based on an assumption of 50 €/ton gate fee paid to the MSW incinerator.

| Region                        | Biomass costs [€/MWh <sub>th</sub> ] |               |                |
|-------------------------------|--------------------------------------|---------------|----------------|
|                               | Solid waste                          | Solid biomass | Biogas sources |
| Total area (weighted average) | -10.1                                | 9.7           | 1.9            |
| CA-West                       | -9.8                                 | 13.4          | 0.0            |
| CA-East                       | -9.8                                 | 13.4          | 0.0            |
| US-New England & New York     | -10.2                                | 10.5          | 0.6            |
| US-Mid-Atlantics              | -10.2                                | 10.5          | 0.6            |
| US-Carolinas                  | -10.2                                | 10.5          | 0.6            |
| US-Southern                   | -10.2                                | 10.5          | 0.6            |
| US-TVA                        | -10.2                                | 10.5          | 0.6            |
| US-Midwest                    | -10.2                                | 10.5          | 0.6            |
| US-Central                    | -10.2                                | 10.5          | 0.6            |
| US-Texas                      | -10.2                                | 10.5          | 0.6            |
| US-Southwest                  | -10.2                                | 10.5          | 0.6            |
| US-Northwest                  | -10.2                                | 10.5          | 0.6            |
| US-California                 | -10.2                                | 10.5          | 0.6            |

|                                 |       |      |     |
|---------------------------------|-------|------|-----|
| US-Alaska                       | -10.2 | 10.5 | 0.6 |
| US-Hawaii                       | -10.2 | 10.5 | 0.6 |
| US-Gulf                         | -10.2 | 10.5 | 0.6 |
| MX-Noroeste (Northwest)         | -10.2 | 5.3  | 7.2 |
| MX-Noreste (North)              | -10.2 | 5.3  | 7.2 |
| MX-Centro-Occidente (Center)    | -10.2 | 5.4  | 7.2 |
| MX-Centro & Sur-Sureste (South) | -10.2 | 5.5  | 7.2 |

**Table S8:** Average full load hours (FLH) and LCOE for single-axis tracking PV, optimally tilted PV, solar CSP and wind power plants in North America by 2030.

| Region                              | Pop.<br>[mio. Pop] | Electr.<br>demand<br>[TWh] | PV-<br>single-<br>axis<br>FLH | PV optimally<br>tilted<br>FLH | CSP<br>FLH | Wind<br>FLH | PV single-<br>axis<br>LCOE<br>[€/MWh] | PV optimally<br>tilted<br>LCOE<br>[€/MWh] | CSP<br>LCOE<br>[€/MWh] | Wind<br>LCOE<br>[€/MWh] |
|-------------------------------------|--------------------|----------------------------|-------------------------------|-------------------------------|------------|-------------|---------------------------------------|-------------------------------------------|------------------------|-------------------------|
| Total area                          | 494                | 6059                       | 1977                          | 1544                          | 1861       | 2848        | 30                                    | 34                                        | 66                     | 40                      |
| CA-West                             | 11                 | 189                        | 1424                          | 1113                          | 1295       | 3115        | 40                                    | 45                                        | 90                     | 34                      |
| CA-East                             | 24                 | 372                        | 1555                          | 1258                          | 1410       | 3972        | 37                                    | 40                                        | 83                     | 27                      |
| US-New England &<br>New York        | 34                 | 307                        | 1597                          | 1317                          | 1440       | 2144        | 36                                    | 38                                        | 81                     | 49                      |
| US-Mid-Atlantics                    | 50                 | 680                        | 1616                          | 1353                          | 1417       | 2552        | 35                                    | 37                                        | 83                     | 41                      |
| US-Carolinas                        | 14                 | 243                        | 1754                          | 1456                          | 1575       | 2295        | 32                                    | 35                                        | 74                     | 46                      |
| US-Southern                         | 34                 | 514                        | 1903                          | 1536                          | 1715       | 2000        | 30                                    | 33                                        | 68                     | 53                      |
| US-TVA                              | 11                 | 209                        | 1732                          | 1427                          | 1543       | 2310        | 33                                    | 35                                        | 76                     | 46                      |
| US-Midwest                          | 51                 | 746                        | 1755                          | 1408                          | 1580       | 3944        | 32                                    | 36                                        | 74                     | 27                      |
| US-Central                          | 9                  | 150                        | 1983                          | 1562                          | 1850       | 4178        | 29                                    | 32                                        | 63                     | 25                      |
| US-Texas                            | 26                 | 428                        | 2168                          | 1698                          | 2039       | 3752        | 26                                    | 30                                        | 57                     | 28                      |
| US-Southwest                        | 35                 | 543                        | 2348                          | 1780                          | 2354       | 3264        | 24                                    | 28                                        | 50                     | 32                      |
| US-Northwest                        | 25                 | 379                        | 2160                          | 1652                          | 2069       | 3423        | 26                                    | 31                                        | 57                     | 31                      |
| US-California                       | 38                 | 299                        | 2347                          | 1758                          | 2386       | 2192        | 24                                    | 29                                        | 49                     | 48                      |
| US-Alaska                           | 1                  | 7                          | 1330                          | 966                           | 1229       | 3478        | 43                                    | 52                                        | 95                     | 30                      |
| US-Hawaii                           | 1                  | 11                         | 2468                          | 1812                          | 2337       | 2889        | 23                                    | 28                                        | 50                     | 37                      |
| US-Gulf                             | 11                 | 211                        | 1832                          | 1496                          | 1666       | 2013        | 31                                    | 34                                        | 70                     | 53                      |
| MX-Noroeste<br>(Northwest)          | 10                 | 115                        | 2475                          | 1842                          | 2548       | 1923        | 23                                    | 27                                        | 46                     | 55                      |
| MX-Noreste (North)                  | 17                 | 320                        | 2371                          | 1853                          | 2313       | 2808        | 24                                    | 27                                        | 51                     | 38                      |
| MX-Centro-Occidente<br>(Center)     | 28                 | 163                        | 2419                          | 1837                          | 2290       | 2698        | 24                                    | 27                                        | 51                     | 39                      |
| MX-Centro & Sur-<br>Sureste (South) | 65                 | 173                        | 2298                          | 1762                          | 2173       | 2019        | 25                                    | 29                                        | 54                     | 52                      |

**Table S9:** Lower limits of installed capacities in North America sub-regions.

| Region     | Installed capacity [MW] |         |            |                        |                  |
|------------|-------------------------|---------|------------|------------------------|------------------|
|            | Solar PV                | Wind    | Hydro dams | Hydro RoR <sup>1</sup> | PHS <sup>2</sup> |
| Total area | 20573.6                 | 73779.6 | 125483.2   | 29165.2                | 18023.4          |
| CA-West    | 0.0                     | 2228.0  | 13687.7    | 5779.6                 | 0.0              |

<sup>1</sup> RoR = Run-of-River

<sup>2</sup> PHS = Pumped Hydroelectric Storage

|                                 |        |         |         |         |        |
|---------------------------------|--------|---------|---------|---------|--------|
| CA-East                         | 1895.6 | 6723.5  | 35120.3 | 9300.9  | 174    |
| US-New England & New York       | 580.7  | 2473.5  | 6291.4  | 166.2   | 1680.0 |
| US-Mid-Atlantics                | 1183.0 | 2457.1  | 4001.5  | 805.8   | 5669.8 |
| US-Carolinas                    | 771.5  | 0.0     | 3940.8  | 179.0   | 2356.2 |
| US-Southern                     | 188.4  | 0.0     | 4768.4  | 233.0   | 1723.0 |
| US-TVA                          | 28.7   | 29.0    | 2893.4  | 332.0   | 0.0    |
| US-Midwest                      | 168.3  | 17760.3 | 3341.7  | 70.3    | 2312.0 |
| US-Central                      | 1.0    | 6809.0  | 708.1   | 29.0    | 260    |
| US-Texas                        | 125.0  | 13068.9 | 387.9   | 0.0     | 0.0    |
| US-Southwest                    | 1313.9 | 1192.7  | 2842.8  | 111.5   | 0.0    |
| US-Northwest                    | 9060.2 | 11948.4 | 24144.3 | 11363.9 | 944.5  |
| US-California                   | 5018.5 | 6456.4  | 8937.5  | 755.6   | 2903.9 |
| US-Alaska                       | 0.0    | 44.3    | 381.2   | 15.0    | 0.0    |
| US-Hawaii                       | 47.5   | 207.1   | 5.6     | 12.3    | 0.0    |
| US-Gulf                         | 0.9    | 0.1     | 1291.4  | 0.0     | 0.0    |
| MX-Noroeste (Northwest)         | 46.8   | 10.6    | 931.6   | 9.6     | 0.0    |
| MX-Noreste (North)              | 17.3   | 76.0    | 125.5   | 0.0     | 0.0    |
| MX-Centro-Occidente (Center)    | 5.8    | 150.4   | 2940.7  | 1.4     | 0.0    |
| MX-Centro & Sur-Sureste (South) | 120.7  | 2144.3  | 8741.5  | 0.0     | 0.0    |

**Table S10:** Upper limits on installable capacities in the North America in units of  $\text{GW}_{\text{th}}$  for CSP and  $\text{GW}_{\text{el}}$  for all other technologies.

| Region                          | area                    | Limits [GW] |          |        |           |            |      |
|---------------------------------|-------------------------|-------------|----------|--------|-----------|------------|------|
|                                 | [1000 km <sup>2</sup> ] | Solar CSP   | Solar PV | Wind   | Hydro RoR | Hydro dams | PHS  |
| Total area                      | 22035747                | 198321.7    | 99160.9  | 7404.0 | 43.7      | 188.2      | 36.0 |
| CA-West                         | 6827155                 | 61444.4     | 30722.2  | 2293.9 | 8.7       | 20.5       | 0.0  |
| CA-East                         | 3152421                 | 28371.8     | 14185.9  | 1059.2 | 14.0      | 52.7       | 0.3  |
| US-New England & New York       | 327560                  | 2948.0      | 1474.0   | 110.1  | 0.2       | 9.4        | 3.4  |
| US-Mid-Atlantics                | 342403                  | 3081.6      | 1540.8   | 115.0  | 1.2       | 6.0        | 11.3 |
| US-Carolinas                    | 222295                  | 2000.7      | 1000.3   | 74.7   | 0.3       | 5.9        | 4.7  |
| US-Southern                     | 460040                  | 4140.4      | 2070.2   | 154.6  | 0.3       | 7.2        | 3.4  |
| US-TVA                          | 213823                  | 1924.4      | 962.2    | 71.8   | 0.5       | 4.3        | 0.0  |
| US-Midwest                      | 1599070                 | 14391.6     | 7195.8   | 537.3  | 0.1       | 5.0        | 4.6  |
| US-Central                      | 594514                  | 5350.6      | 2675.3   | 199.8  | 0.0       | 1.1        | 0.5  |
| US-Texas                        | 695673                  | 6261.1      | 3130.5   | 233.7  | 0.0       | 0.6        | 0.0  |
| US-Southwest                    | 1311066                 | 11799.6     | 5899.8   | 440.5  | 0.2       | 4.3        | 0.0  |
| US-Northwest                    | 2066206                 | 18595.9     | 9297.9   | 694.2  | 17.0      | 36.2       | 1.9  |
| US-California                   | 423970                  | 3815.7      | 1907.9   | 142.5  | 1.1       | 13.4       | 5.8  |
| US-Alaska                       | 1700131                 | 15301.2     | 7650.6   | 571.2  | 0.0       | 0.6        | 0.0  |
| US-Hawaii                       | 28313                   | 254.8       | 127.4    | 9.5    | 0.0       | 0.0        | 0.0  |
| US-Gulf                         | 397458                  | 3577.1      | 1788.6   | 133.5  | 0.0       | 1.9        | 0.0  |
| MX-Noroeste (Northwest)         | 317774                  | 2860.0      | 1430.0   | 106.8  | 0.0       | 1.4        | 0.0  |
| MX-Noreste (North)              | 444063                  | 3996.6      | 1998.3   | 149.2  | 0.0       | 0.2        | 0.0  |
| MX-Centro-Occidente (Centre)    | 355014                  | 3195.1      | 1597.6   | 119.3  | 0.0       | 4.4        | 0.0  |
| MX-Centro & Sur-Sureste (South) | 556798                  | 5011.2      | 2505.6   | 187.1  | 0.0       | 13.1       | 0.0  |

**Table S11:** Annual industrial gas demand and water demand for the year 2030.

|                           | Annual gas demand |                      | Annual electricity demand for gas synthesis | Annual water desalination demand | Annual electricity demand for water desalination |
|---------------------------|-------------------|----------------------|---------------------------------------------|----------------------------------|--------------------------------------------------|
|                           | [Mtoe]            | [TWh <sub>th</sub> ] | [TWh <sub>el</sub> ]                        | [Mil. m <sup>3</sup> ]           | [TWh <sub>el</sub> ]                             |
| Total                     | 183.5             | 2134.0               | 3783.7                                      | 83607.2                          | 462.0                                            |
| CA-West                   | 7.1               | 82.9                 | 149.3                                       | 230.7                            | 1.4                                              |
| CA-East                   | 15.6              | 181.8                | 327.4                                       | 506.0                            | 0.0                                              |
| US-New England & New York | 14.7              | 171.4                | 303.5                                       | 6266.4                           | 0.0                                              |
| US-Mid-Atlantics          | 21.6              | 251.1                | 444.8                                       | 9182.2                           | 30.6                                             |
| US-Carolinas              | 6.2               | 72.7                 | 128.7                                       | 2657.6                           | 0.0                                              |

|                                 |      |       |       |         |       |
|---------------------------------|------|-------|-------|---------|-------|
| US-Southern                     | 14.7 | 171.0 | 303.0 | 6252.9  | 18.8  |
| US-TVA                          | 4.7  | 54.4  | 96.4  | 1989.5  | 0.0   |
| US-Midwest                      | 22.0 | 256.2 | 455.8 | 9368.6  | 43.2  |
| US-Central                      | 3.7  | 43.0  | 77.8  | 1570.8  | 8.6   |
| US-Texas                        | 11.3 | 130.9 | 233.7 | 4784.1  | 31.2  |
| US-Southwest                    | 15.0 | 174.2 | 310.4 | 6370.1  | 56.9  |
| US-Northwest                    | 11.0 | 127.6 | 225.9 | 4664.5  | 44.6  |
| US-California                   | 16.4 | 191.0 | 338.6 | 6983.9  | 29.5  |
| US-Alaska                       | 0.3  | 3.7   | 6.5   | 134.3   | 0.0   |
| US-Hawaii                       | 0.6  | 7.0   | 12.5  | 255.6   | 0.0   |
| US-Gulf                         | 4.5  | 52.9  | 94.0  | 1934.3  | 7.3   |
| MX-Noroeste (Northwest)         | 1.1  | 13.4  | 22.6  | 1684.7  | 7.5   |
| MX-Noreste (North)              | 2.0  | 22.8  | 40.3  | 2879.8  | 22.8  |
| MX-Centro-Occidente (Center)    | 3.2  | 37.8  | 63.7  | 4761.5  | 45.2  |
| MX-Centro & Sur-Sureste (South) | 7.6  | 88.2  | 148.7 | 11129.8 | 114.5 |

**Table S12:** Total LCOE components in all sub-regions of North America.

| Region-wide                         | LCOE primary<br>[€/MWh] | LCOC<br>[€/MWh] | LCOS<br>[€/MWh] | LCOT<br>[€/MWh] | LCOE total<br>[€/MWh] |                                  |
|-------------------------------------|-------------------------|-----------------|-----------------|-----------------|-----------------------|----------------------------------|
| Area weighted average               | 37.5                    | 2.8             | 22.9            | 0.0             | 63.2                  |                                  |
| CA-West                             | 41.1                    | 1.3             | 7.0             | 0.0             | 49.4                  |                                  |
| CA-East                             | 34.6                    | 2.7             | 6.0             | 0.0             | 43.3                  |                                  |
| US-New England &<br>New York        | 45.4                    | 2.9             | 22.2            | 0.0             | 70.5                  |                                  |
| US-Mid-Atlantic                     | 40.8                    | 3.6             | 31.4            | 0.0             | 75.8                  |                                  |
| US-Carolinas                        | 41.8                    | 4.1             | 29.0            | 0.0             | 74.9                  |                                  |
| US-Southern                         | 40.0                    | 3.8             | 31.9            | 0.0             | 75.7                  |                                  |
| US-TVA                              | 41.2                    | 2.7             | 29.4            | 0.0             | 73.3                  |                                  |
| US-Midwest                          | 33.6                    | 2.5             | 20.9            | 0.0             | 57.0                  |                                  |
| US-Central                          | 34.2                    | 1.5             | 21.6            | 0.0             | 57.3                  |                                  |
| US-Texas                            | 30.7                    | 2.6             | 26.8            | 0.0             | 60.1                  |                                  |
| US-Southwest                        | 31.3                    | 3.4             | 24.7            | 0.0             | 59.4                  |                                  |
| US-Northwest                        | 39.0                    | 2.1             | 9.2             | 0.0             | 50.3                  |                                  |
| US-California                       | 41.4                    | 2.9             | 20.2            | 0.0             | 64.5                  |                                  |
| US-Alaska                           | 41.2                    | 1.6             | 8.8             | 0.0             | 51.6                  |                                  |
| US-Hawaii                           | 36.1                    | 2.1             | 27.6            | 0.0             | 65.8                  |                                  |
| US-Gulf                             | 43.8                    | 3.1             | 30.4            | 0.0             | 77.3                  |                                  |
| MX-Noroeste<br>(Northwest)          | 33.7                    | 2.0             | 32.7            | 0.0             | 68.4                  |                                  |
| MX-Noreste (North)                  | 33.9                    | 2.7             | 26.4            | 0.0             | 63.0                  |                                  |
| MX-Centro-Occidente<br>(Center)     | 39.4                    | 2.8             | 18.6            | 0.0             | 60.8                  |                                  |
| MX-Centro & Sur-<br>Sureste (South) | 40.7                    | 0.9             | 13.3            | 0.0             | 54.9                  |                                  |
| Country-wide                        | LCOE primary<br>[€/MWh] | LCOC<br>[€/MWh] | LCOS<br>[€/MWh] | LCOT<br>[€/MWh] | LCOE total<br>[€/MWh] | export (-)/<br>import (+)<br>[%] |
| Area weighted average               | 35.7                    | 2.5             | 15.0            | 3.1             | 56.3                  | 21.5                             |
| CA-West                             | 41.0                    | 1.3             | 7.0             | 0.0             | 49.3                  | 0.2                              |
| CA-East                             | 34.5                    | 2.5             | 6.2             | 0.0             | 43.2                  | -0.1                             |
| US-New England &<br>New York        | 46.3                    | 1.9             | 12.7            | 2.8             | 63.7                  | 17.7                             |
| US-Mid-Atlantic                     | 49.5                    | 1.7             | 12.7            | 8.9             | 72.8                  | 48.6                             |
| US-Carolinas                        | 43.9                    | 2.6             | 14.6            | 2.8             | 63.9                  | 18.1                             |
| US-Southern                         | 38.9                    | 1.9             | 20.3            | 2.9             | 64.0                  | 16.4                             |
| US-TVA                              | 44.0                    | 5.8             | 16.8            | 26.3            | 92.9                  | 72.3                             |
| US-Midwest                          | 30.5                    | 2.7             | 16.1            | 3.5             | 52.8                  | -35.9                            |
| US-Central                          | 28.5                    | 2.9             | 16.7            | 4.0             | 52.1                  | -37.4                            |
| US-Texas                            | 30.4                    | 2.9             | 17.5            | 2.2             | 53.0                  | -18.9                            |
| US-Southwest                        | 32.5                    | 2.9             | 17.3            | 1.2             | 53.9                  | 4.4                              |
| US-Northwest                        | 37.7                    | 1.8             | 7.7             | 1.6             | 48.8                  | -13.6                            |
| US-California                       | 34.3                    | 3.1             | 14.6            | 3.0             | 55.0                  | 15.6                             |

|                       |              |         |         |         |            |                           |
|-----------------------|--------------|---------|---------|---------|------------|---------------------------|
| US-Alaska             | 40.0         | 2.0     | 5.7     | 0.8     | 48.5       | -0.9                      |
| US-Hawaii             | 36.4         | 2.0     | 24.8    | 0.6     | 63.8       | 1.6                       |
| US-Gulf               | 39.8         | 4.1     | 27.2    | 39.8    | 110.9      | 80.1                      |
| MX-Noroeste           |              |         |         |         |            |                           |
| (Northwest)           | 30.5         | 1.4     | 32.3    | 1.6     | 65.8       | 9.2                       |
| MX-Noreste (North)    | 35.9         | 3.5     | 18.4    | 0.9     | 58.7       | -3.3                      |
| MX-Centro-Occidente   |              |         |         |         |            |                           |
| (Center)              | 39.9         | 1.9     | 13.6    | 1.0     | 56.4       | 0.6                       |
| MX-Centro & Sur-      |              |         |         |         |            |                           |
| Sureste (South)       | 42.3         | 0.9     | 10.5    | 1.5     | 55.2       | -0.5                      |
| Area-wide             | LCOE primary | LCOC    | LCOS    | LCOT    | LCOE total | export (-)/<br>import (+) |
|                       | [€/MWh]      | [€/MWh] | [€/MWh] | [€/MWh] | [€/MWh]    | [%]                       |
| Area weighted average | 34.6         | 2.1     | 12.4    | 3.9     | 53.0       | 27.4                      |
| CA-West               | 40.8         | 1.1     | 2.4     | 1.9     | 46.2       | -8.3                      |
| CA-East               | 31.3         | 1.4     | 3.7     | 5.0     | 41.4       | -62.4                     |
| US-New England &      |              |         |         |         |            |                           |
| New York              | 40.1         | 2.5     | 19.5    | 16.7    | 78.8       | 61.8                      |
| US-Mid-Atlantic       | 43.6         | 1.1     | 18.1    | 19.4    | 82.2       | 66.1                      |
| US-Carolinas          | 42.5         | 1.7     | 15.3    | 5.4     | 64.9       | 36.4                      |
| US-Southern           | 40.9         | 2.2     | 17.2    | 2.8     | 63.1       | 18.2                      |
| US-TVA                | 44.6         | 5.2     | 14.1    | 21.0    | 84.9       | 68.8                      |
| US-Midwest            | 31.0         | 2.2     | 11.9    | 2.3     | 47.4       | -22.1                     |
| US-Central            | 28.6         | 3.1     | 16.6    | 3.7     | 52.0       | -34.2                     |
| US-Texas              | 31.0         | 2.5     | 18.4    | 1.6     | 53.5       | -6.2                      |
| US-Southwest          | 32.3         | 2.8     | 18.3    | 1.1     | 54.5       | 6.1                       |
| US-Northwest          | 36.4         | 2.1     | 6.3     | 1.7     | 46.5       | -14.1                     |
| US-California         | 34.5         | 3.0     | 13.3    | 3.1     | 53.9       | 17.3                      |
| US-Alaska             | 39.2         | 2.0     | 6.1     | 0.9     | 48.2       | -1.7                      |
| US-Hawaii             | 36.4         | 1.9     | 24.9    | 0.5     | 63.7       | 1.4                       |
| US-Gulf               | 44.2         | 2.0     | 11.4    | 8.9     | 66.5       | 51.1                      |
| MX-Noroeste           |              |         |         |         |            |                           |
| (Northwest)           | 30.8         | 2.3     | 26.1    | 1.9     | 61.1       | 8.8                       |
| MX-Noreste (North)    | 35.5         | 2.6     | 17.0    | 1.3     | 56.4       | 3.9                       |
| MX-Centro-Occidente   |              |         |         |         |            |                           |
| (Center)              | 39.8         | 1.8     | 14.2    | 1.0     | 56.8       | 2.5                       |
| MX-Centro & Sur-      |              |         |         |         |            |                           |
| Sureste (South)       | 40.5         | 1.0     | 11.7    | 1.3     | 54.5       | -2.3                      |
| Integrated scenario   | LCOE primary | LCOC    | LCOS    | LCOT    | LCOE total | export (-)/<br>import (+) |
|                       | [€/MWh]      | [€/MWh] | [€/MWh] | [€/MWh] | [€/MWh]    | [%]                       |
| Area wighted average  | 32.5         | 1.2     | 5.1     | 3.4     | 42.2       | 26.8                      |
| CA-West               | 38.5         | 0.2     | 1.4     | 0.6     | 40.7       | 4.5                       |
| CA-East               | 30.1         | 0.9     | 1.0     | 4.1     | 36.1       | -62.2                     |
| US-New England &      |              |         |         |         |            |                           |
| New York              | 39.9         | 1.0     | 19.2    | 38.2    | 98.3       | 81.5                      |
| US-Mid-Atlantic       | 42.0         | 0.3     | 9.2     | 14.1    | 65.6       | 65.3                      |
| US-Carolinas          | 40.5         | 1.1     | 6.5     | 3.6     | 51.7       | 30.2                      |
| US-Southern           | 35.6         | 1.1     | 9.3     | 2.6     | 48.6       | 22.8                      |
| US-TVA                | 37.3         | 3.1     | 17.4    | 43.1    | 100.9      | 83.9                      |
| US-Midwest            | 30.1         | 1.1     | 3.3     | 2.2     | 36.7       | -29.5                     |
| US-Central            | 28.0         | 1.9     | 5.6     | 3.4     | 38.9       | -46.3                     |
| US-Texas              | 30.2         | 1.4     | 4.5     | 1.6     | 37.7       | -15.8                     |
| US-Southwest          | 31.8         | 1.9     | 6.4     | 0.7     | 40.8       | 0.5                       |
| US-Northwest          | 35.3         | 0.8     | 2.4     | 1.3     | 39.8       | -14.9                     |
| US-California         | 29.0         | 1.0     | 4.8     | 2.5     | 37.3       | 21.1                      |
| US-Alaska             | 37.6         | 1.3     | 2.6     | 0.0     | 41.5       | 0.0                       |
| US-Hawaii             | 28.3         | 1.2     | 15.4    | 0.0     | 44.9       | 0.0                       |
| US-Gulf               | 35.2         | 1.1     | 11.4    | 16.7    | 64.4       | 70.4                      |
| MX-Noroeste           |              |         |         |         |            |                           |
| (Northwest)           | 28.1         | 1.2     | 21.4    | 1.7     | 52.4       | 5.7                       |
| MX-Noreste (North)    | 34.9         | 1.7     | 13.0    | 1.1     | 50.7       | 0.3                       |

|                                     |      |     |     |     |      |      |
|-------------------------------------|------|-----|-----|-----|------|------|
| MX-Centro-Occidente<br>(Center)     | 37.6 | 2.0 | 7.5 | 1.1 | 48.2 | -2.9 |
| MX-Centro & Sur-<br>Sureste (South) | 35.1 | 0.8 | 6.5 | 1.0 | 43.4 | 7.7  |

**Table S13:** Prosumer electricity costs, installed capacities and electricity utilization in North America.

| Prosumers parameters                             | Residential | Commercial | Industrial |
|--------------------------------------------------|-------------|------------|------------|
| Electricity price [€/kWh]                        | 0.170       | 0.174      | 0.153      |
| PV LCOE [€/kWh]                                  | 0.029       | 0.039      | 0.037      |
| Self-consumption PV LCOE [€/kWh]                 | 0.039       | 0.049      | 0.045      |
| Self-consumption PV and Battery LCOE [€/kWh]     | 0.071       | 0.086      | 0.078      |
| Self-consumption LCOE [€/kWh]                    | 0.070       | 0.086      | 0.078      |
| Benefit [€/kWh]                                  | 0.100       | 0.088      | 0.075      |
| Installed capacities                             | Residential | Commercial | Industrial |
| PV [GW]                                          | 285.2       | 212.9      | 313.8      |
| Battery storage [GWh]                            | 480.2       | 389.8      | 541.0      |
| Generation                                       | Residential | Commercial | Industrial |
| PV [TWh]                                         | 425.8       | 319.0      | 492.1      |
| Battery storage [TWh]                            | 143.3       | 114.6      | 163.1      |
| Excess [TWh]                                     | 92.4        | 51.9       | 70.7       |
| Utilization                                      | Residential | Commercial | Industrial |
| Self-consumption of generated PV electricity [%] | 74.6        | 79.7       | 81.9       |
| Self-coverage market segment [%]                 | 17.0        | 16.8       | 15.1       |
| Self-coverage operators [%]                      | 85.0        | 84.0       | 75.3       |

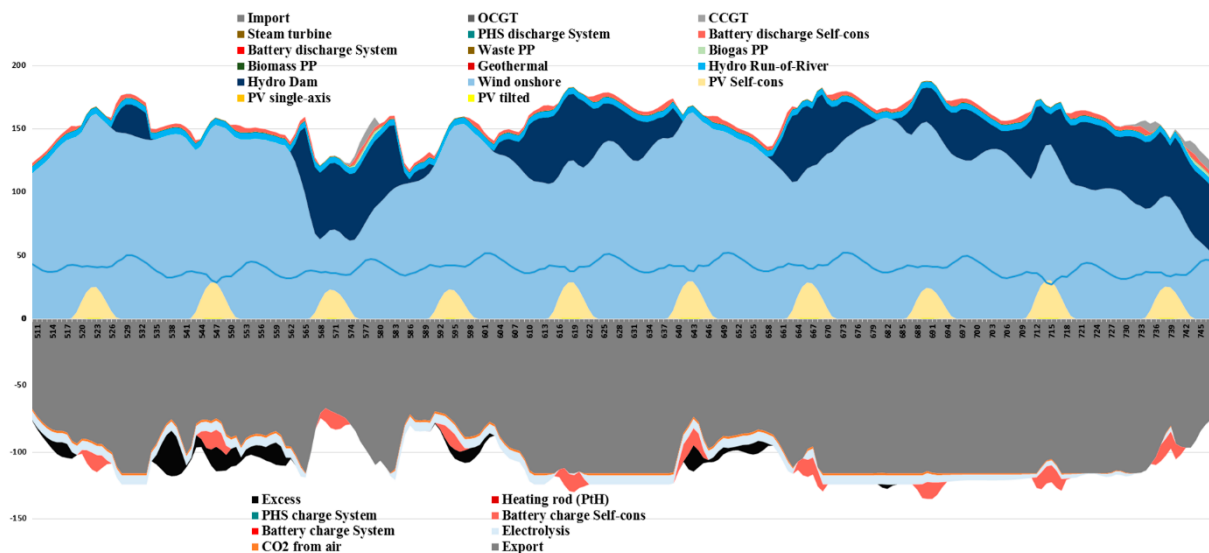
**Table S14:** Overview on storage capacities, throughput and full cycles per year for the four scenarios in North America.

|                       |                |                      | Region-wide | Country-wide | Area-wide | Integrated |
|-----------------------|----------------|----------------------|-------------|--------------|-----------|------------|
| Storage capacities    | Battery SC     | [GWh <sub>el</sub> ] | 1410.9      | 1410.9       | 1410.9    | 1410.9     |
|                       | Battery system | [GWh <sub>el</sub> ] | 1234.4      | 592.9        | 483.3     | 402.4      |
|                       | PHS            | [GWh <sub>el</sub> ] | 34.9        | 34.9         | 34.9      | 24.5       |
|                       | A-CAES         | [GWh <sub>el</sub> ] | 5821.6      | 185.9        | 1.3       | 4.8        |
|                       | Gas            | [GWh <sub>th</sub> ] | 273396.6    | 229590.8     | 174299.2  | 221421.2   |
| Throughput of storage | Battery SC     | [TWh <sub>el</sub> ] | 421.1       | 421.1        | 421.1     | 421.1      |
|                       | Battery system | [TWh <sub>el</sub> ] | 364.2       | 181.9        | 153.4     | 121.4      |
|                       | PHS            | [TWh <sub>el</sub> ] | 7.9         | 7.6          | 8.4       | 5.2        |
|                       | A-CAES         | [TWh <sub>el</sub> ] | 142.9       | 5.2          | 0.03      | 0.1        |
|                       | Gas            | [TWh <sub>th</sub> ] | 555.3       | 494.2        | 378.4     | 40.6       |
| Full cycles per year  | Battery SC     | [-]                  | 298.4       | 298.4        | 298.4     | 298.4      |
|                       | Battery system | [-]                  | 295.0       | 306.8        | 317.3     | 301.7      |
|                       | PHS            | [-]                  | 228.5       | 216.7        | 242.1     | 210.6      |
|                       | A-CAES         | [-]                  | 24.6        | 28.0         | 25.7      | 25.8       |
|                       | Gas            | [-]                  | 2.0         | 2.2          | 2.2       | 0.2        |

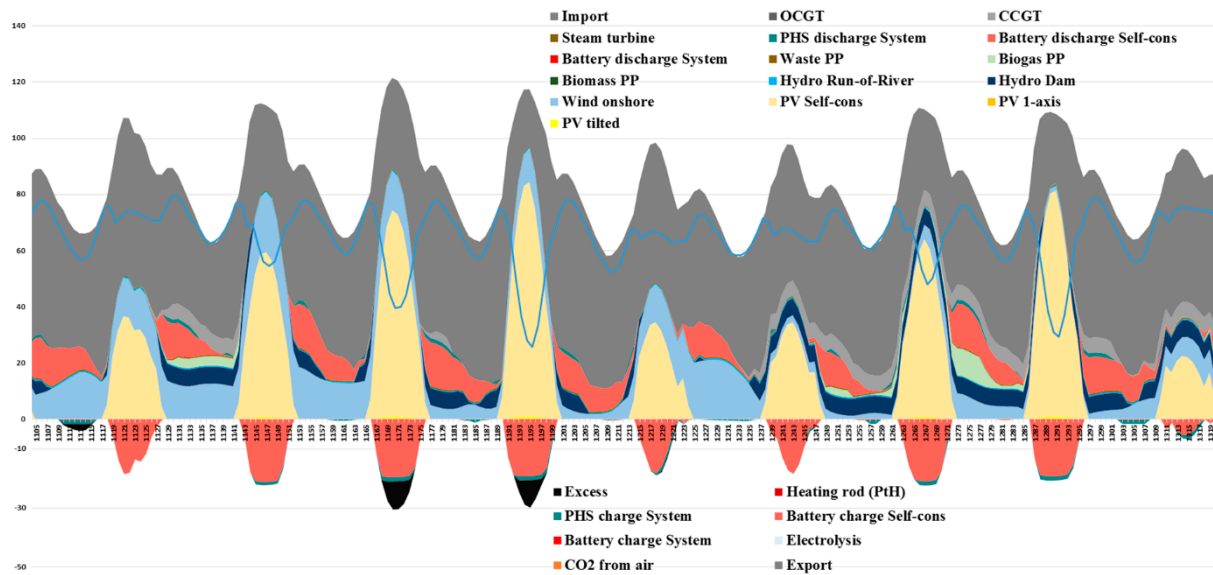
**Table S15:** Electricity transmission line parameters for the area-wide scenario for North America.

| Region 1                  | Region 2         | Length<br>[km] | Capacity<br>[GW] | Utilization<br>[%] |
|---------------------------|------------------|----------------|------------------|--------------------|
| CA-West                   | US-Northwest     | 899.8          | 4.4              | 66                 |
| CA-East                   | US-Midwest       | 742.5          | 25.6             | 62                 |
| US-New England & New York | CA-East          | 424.6          | 90.2             | 88                 |
| US-New England & New York | US-Mid-Atlantics | 82.4           | 64.9             | 86                 |
| US-Mid-Atlantics          | US-Carolinas     | 463.1          | 9.6              | 70                 |
| US-Mid-Atlantics          | US-Midwest       | 660.0          | 4.8              | 60                 |
| US-Carolinas              | US-Southern      | 337.7          | 2.5              | 58                 |

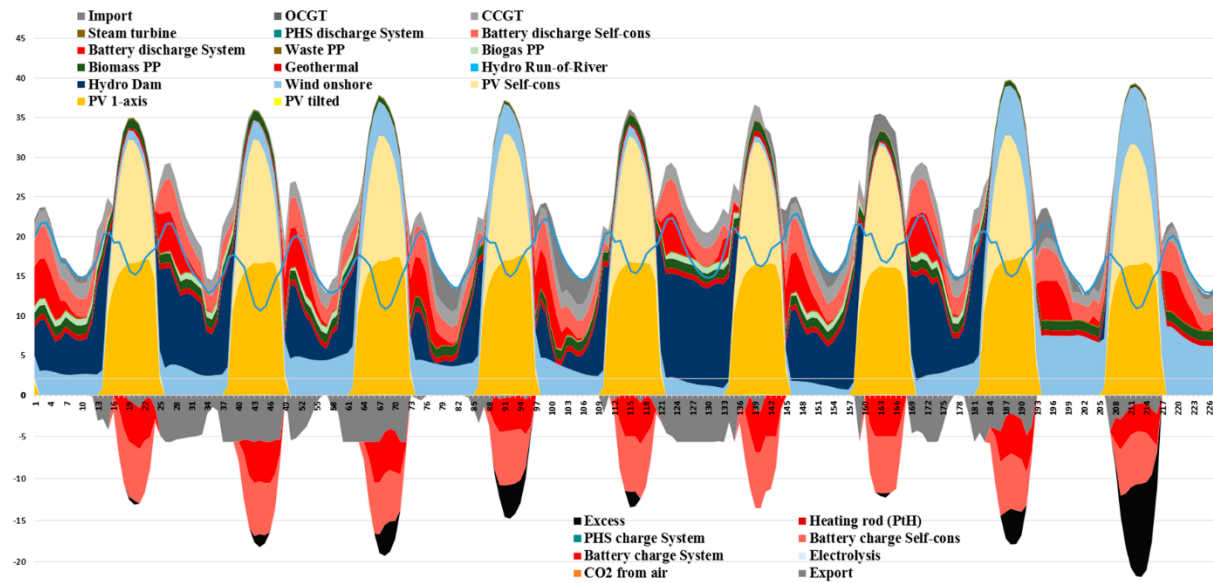
|                              |                                 |        |      |    |
|------------------------------|---------------------------------|--------|------|----|
| US-Carolinas                 | US-TVA                          | 333.3  | 8.4  | 71 |
| US-Southern                  | US-TVA                          | 485.1  | 16.2 | 70 |
| US-TVA                       | US-Midwest                      | 379.5  | 41.8 | 73 |
| US-Midwest                   | CA-West                         | 1486.1 | 7.0  | 71 |
| US-Midwest                   | US-Gulf                         | 838.2  | 5.7  | 66 |
| US-Central                   | US-Midwest                      | 705.1  | 10.4 | 63 |
| US-Texas                     | US-Central                      | 400.4  | 10.4 | 56 |
| US-Southwest                 | US-Central                      | 1036.2 | 10.0 | 69 |
| US-Southwest                 | US-Northwest                    | 1133.0 | 4.1  | 65 |
| US-Northwest                 | US-Midwest                      | 1789.7 | 2.6  | 71 |
| US-California                | US-Southwest                    | 356.4  | 9.2  | 55 |
| US-California                | US-Northwest                    | 1089.0 | 13.7 | 68 |
| US-Alaska                    | CA-West                         | 1530.1 | 0.2  | 63 |
| US-Gulf                      | US-Southern                     | 574.2  | 9.7  | 68 |
| US-Gulf                      | US-Central                      | 574.2  | 11.9 | 70 |
| US-Gulf                      | US-Texas                        | 316.8  | 12.8 | 60 |
| MX-Noroeste (Northwest)      | US-California                   | 124.3  | 4.8  | 52 |
| MX-Noroeste (Northwest)      | MX-Noreste (North)              | 618.2  | 3.2  | 62 |
| MX-Noreste (North)           | US-Texas                        | 658.9  | 8.5  | 65 |
| MX-Noreste (North)           | MX-Centro-Occidente (Center)    | 833.8  | 4.6  | 69 |
| MX-Centro-Occidente (Center) | MX-Centro & Sur-Sureste (South) | 294.8  | 5.6  | 58 |



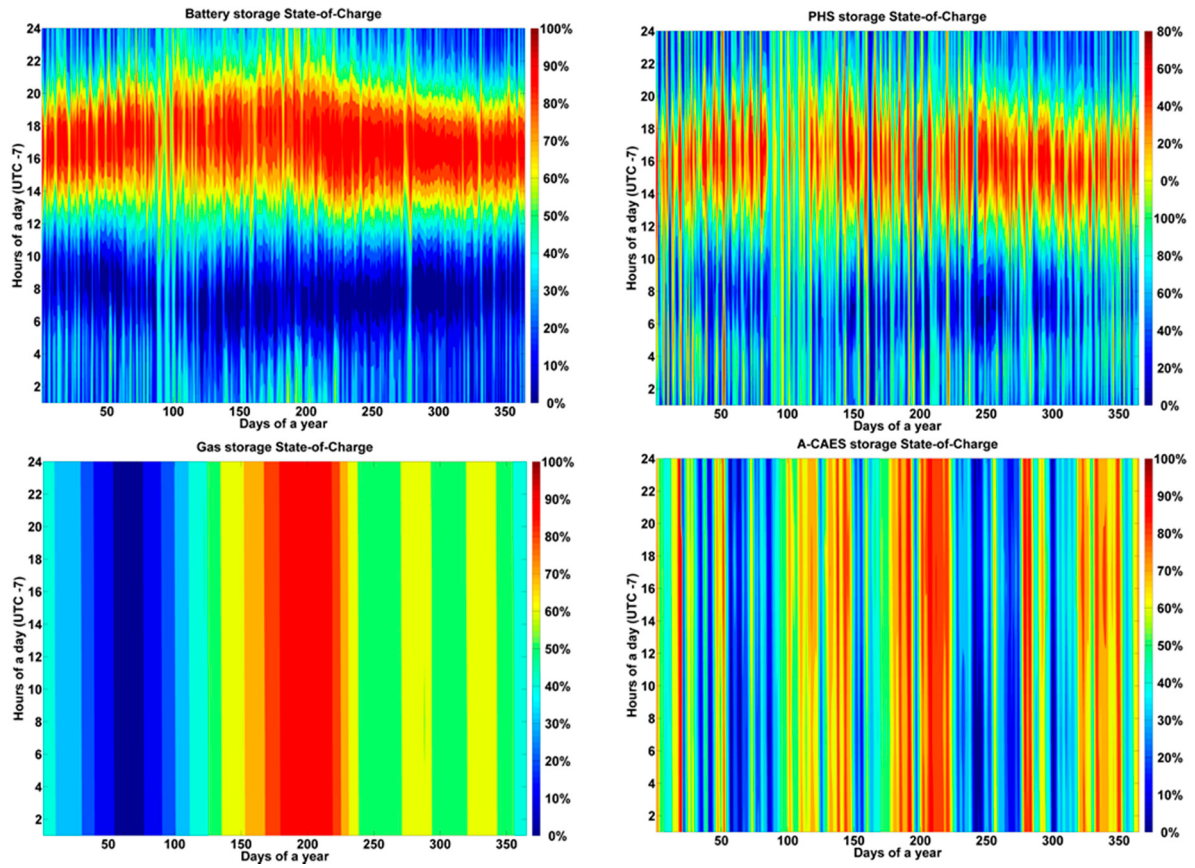
**Figure S1:** Hourly generation profile for a net exporter region, Eastern Canada.



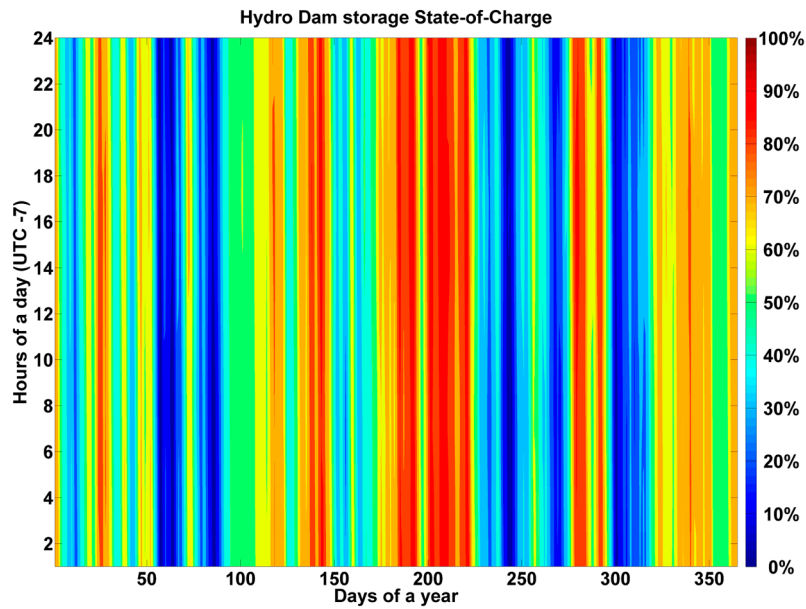
**Figure S2:** Hourly generation profile for a net importer region, US-Mid-Atlantic.



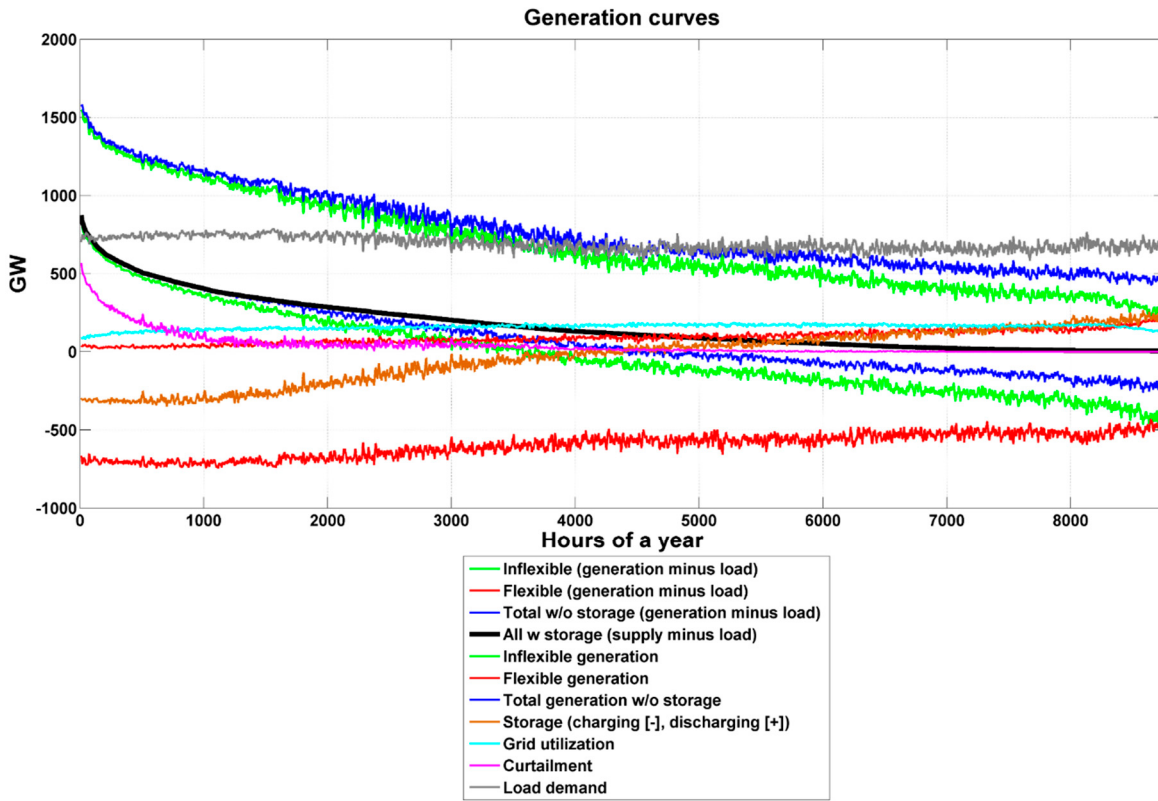
**Figure S3:** Hourly generation profile for Southern Mexico, an example of a balancing region.



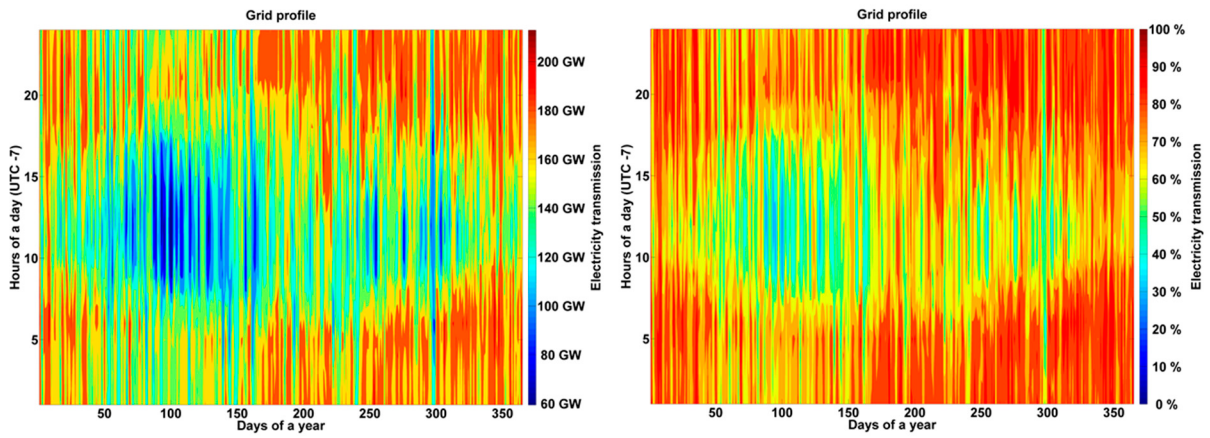
**Figure S4:** Aggregated yearly state-of-charge for storage in area-wide scenario, battery (top left), PHS (top right), gas storage (bottom left) and A-CAES (bottom right).



**Figure S5:** State-of-charge for hydro dams in the area-wide scenario.



**Figure S6:** Electricity generation curves for a whole year for area-wide scenario for North America.



**Figure S7:** Profile for interregional electricity trade between regions with the absolute numbers (left) and with power line utilisation (right) for area-wide scenario for North America.



## References

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